



NIRPS Update to the Space Transportation Association July 16, 2015



Dr. Dale Thomas
Associate Director, Technical
NASA/Marshall Space Flight Center

Grand Challenges Facing Rocket Propulsion

Lack of integrated space strategies across Government Agencies and Departments

Frequent program starts & cancellations

Shuttle retirement

Uncertainty in future needs

Industrial base decline

Overcapacity of production capability

Rising supplier costs

Large solid rocket motor industrial base decline

Lack of multi-Agency vision

Overall decline in aerospace engineer demand

Lack of predictable long-term funding

Lack of sustained technology development

Aging workforce

Lack of defined space missions

Fewer engineers have technology development experience

Difficulty in access to government facilities

Systems infrastructure, supply chain, & skill base challenges

Reduce development & sustainment costs

Foster access to facilities & expertise

Support industrial base competitiveness & resilience

Collaborate across Agencies

Implement an integrated Science & technology plan

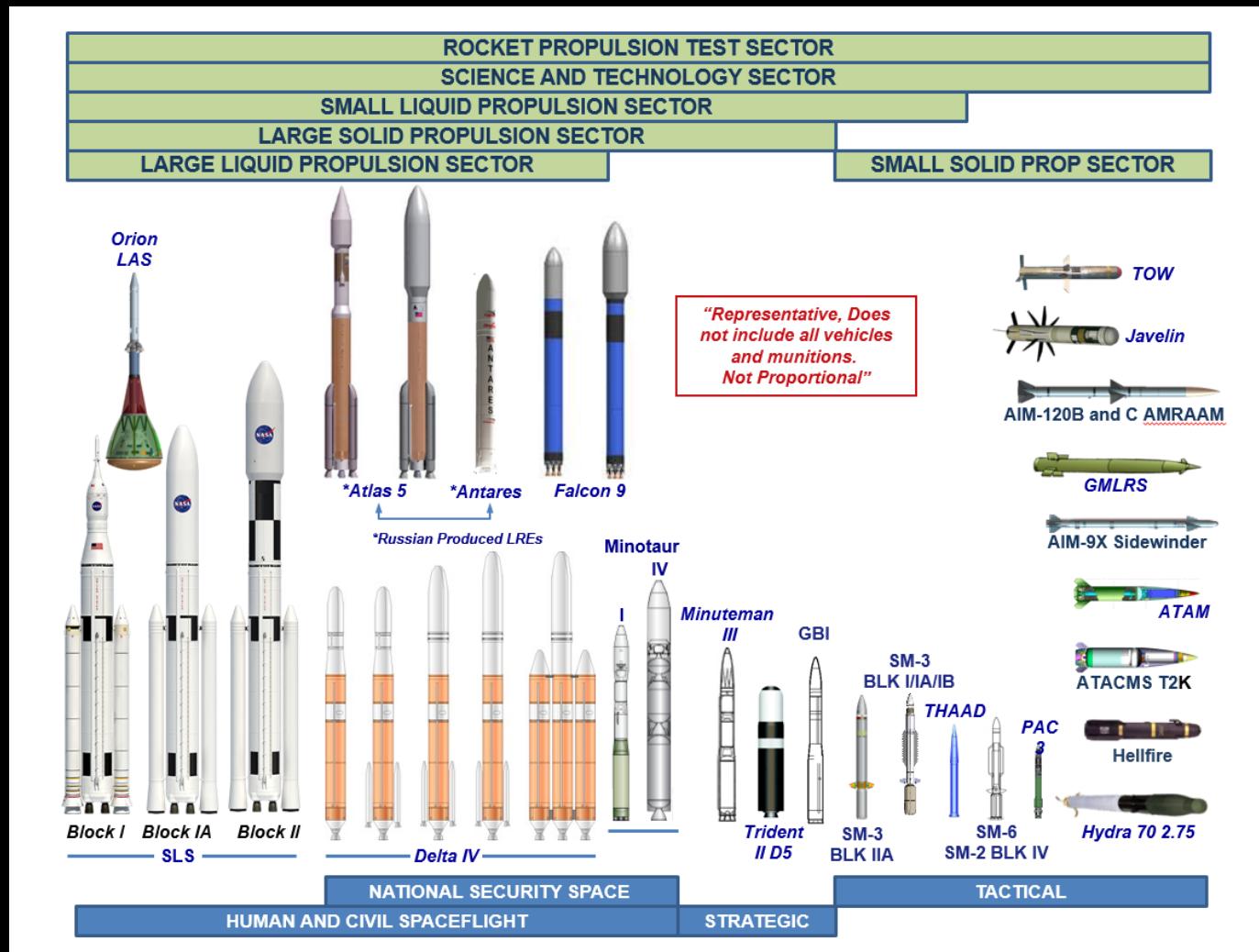
Invigorate the STEM pipeline

Loss of competitiveness in the global market

Addressing the Grand Challenges

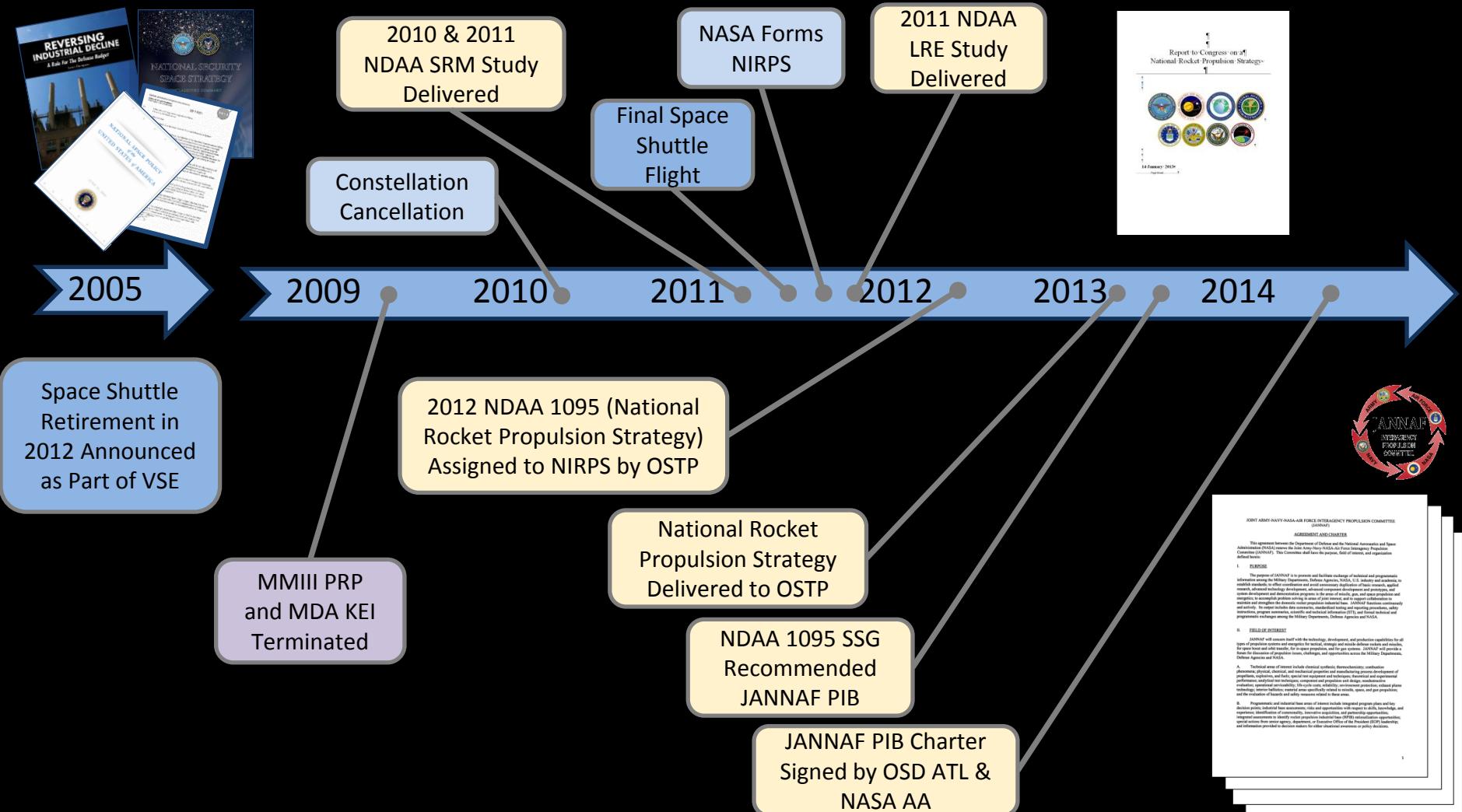
- Continued industry consolidation
- Even more interconnectedness between agencies, sectors and programs
- Limited USG rocket propulsion budgets
- Increasing need to lower costs while improving performance
- USG needs a way to collaborate and understand the whole picture of the RPIB
- JANNAF is a trusted, integrated Government-wide forum
- Augmentation of JANNAF with a Programmatic and Industrial Base (PIB) committee allows leveraging of resources, synergy with technical activities

Highly Interconnected Rocket Propulsion Industrial Base Serving Government and Commercial Needs



Changes in a program can have effects on seemingly unrelated programs

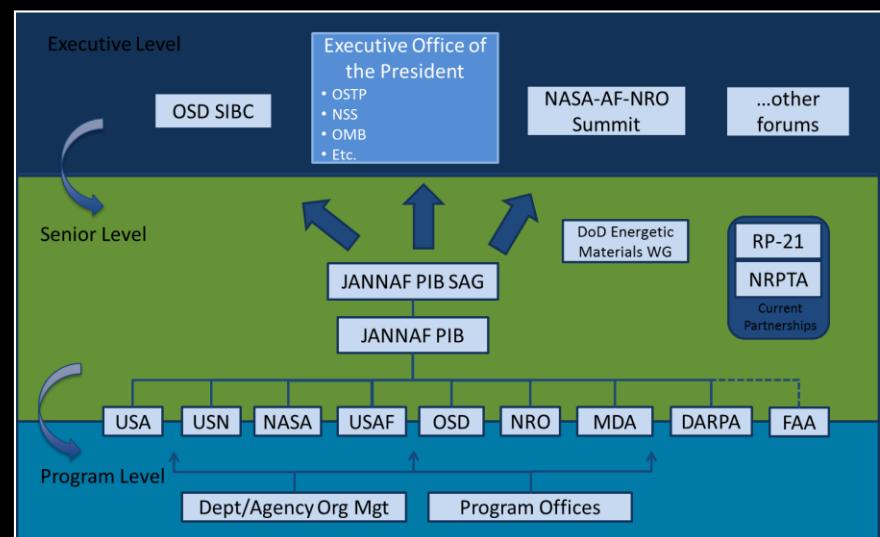
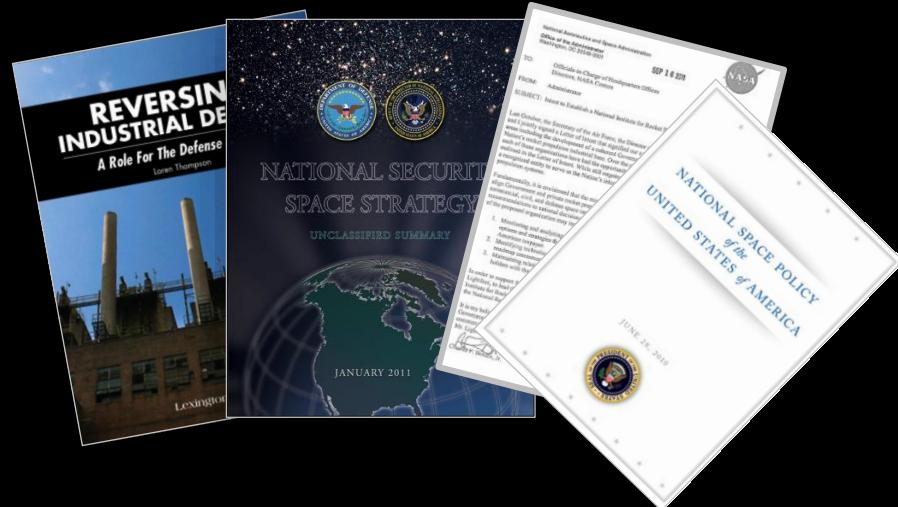
Path to Increased Government Propulsion Collaboration



NASA's NIRPS and JANNAF Programmatic and Industrial Base (PIB) Committee are Spearheading Collaboration

NIRPS and the JANNAF PIB are Executing Tasks of National Importance

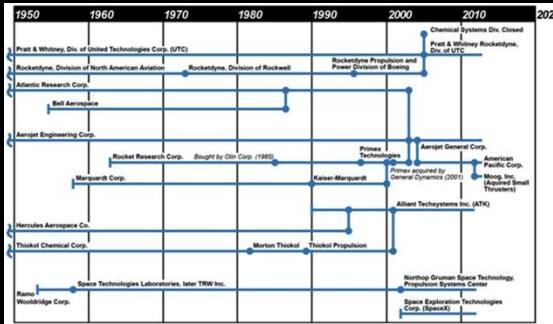
- Congressional and Administration concern about Rocket Propulsion Industrial Base (RPIB)
 - Widespread recognition of the problem
 - Sustainment of the solid rocket motor and liquid rocket engine industrial base is a national challenge that spans multiple departments and agencies of the U.S. Government.
 - Integrated approach among US Government Agencies
- PIB Supports Interagency Communication and Collaboration
 - JANNAF PIB Senior Advisory Group (SAG) established
 - Co-Chaired by NASA & DoD DUSD MIBP
 - **Members from Army, Navy, Air Force, NRO, MDA, OSD, & NASA**
 - JANNAF NASA/DOD PIB Charter Signed: June 2014



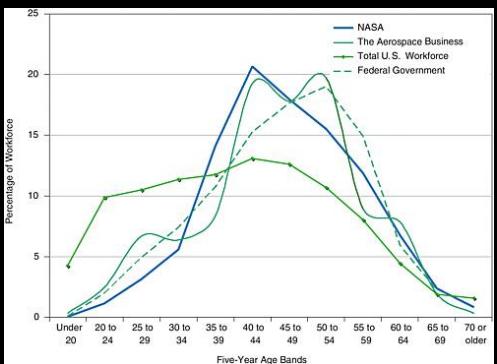
JANNAF Programmatic and Industrial Base Committee Leading Interagency Rocket Propulsion Collaboration



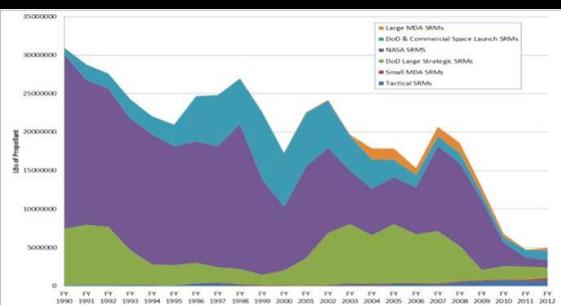
- The June JANNAF general meeting was the first with integrated PIB activities
- The First Senior Advisory Group meeting and presentation is scheduled for July 2015
- Products & Activities:**
 - Integrated (i.e. collated) program plans & key decision points*
 - Industrial base assessments
 - Risks and opportunities with respect to skills, knowledge, and experience.
 - Special actions from senior agency, department, or EOP leadership
 - Provide decision makers information for situational awareness or decisions in a timely and efficient manner
- Working Group Studies**
 - Small Solid Rocket Motor Capabilities (2015 NDAA task)
 - Ammonium Perchlorate industrial base capabilities and alternatives
 - Domestic Boost Propulsion
 - Helium Stewardship Act of 2013 Effects



Consolidating Industry



Aging Workforce



Reduced SRM Production

JANNAF Contract Award

- Contract to provide technical and administrative support to JANNAF was awarded to the Center for Aerospace – Defense Research and Engineering at Johns Hopkins University on June 11, 2015
 - Contract award accomplished in time to ensure a seamless transition to the NASA Contract
- Work has begun on adding IDIQ tasks to the new contract



JOINT ARMY NAVY NASA AIR FORCE

INTERAGENCY PROPULSION COMMITTEE



CADRE

CENTER FOR AEROSPACE - DEFENSE
RESEARCH AND ENGINEERING



JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

NIRPS Provides Propulsion Industrial Base Analysis

Propulsion Supplier Integrated Modeling and Analysis (PropSIMA)

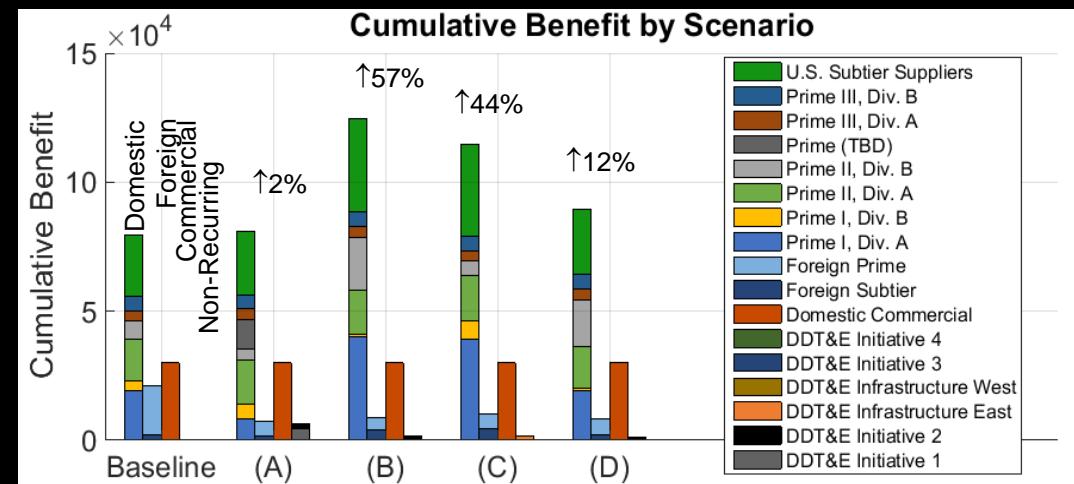
- Supplier Database (over 600) and Simulation Tool for Scenario Analysis
- Managed by NIRPS, with collaboration from USAF
- Building a leading edge capability to model the supply chain and industrial base for rocket propulsion

Previous Studies: PropSIMA assessed impact on RPIB due to three SLS Upper Stage Engine Options

Current Studies: Collaborating with USAF SMC, to analyze and update the suite of vehicles/engines, Courses of Action and results

- Domestic production of hydrocarbon booster propulsion
- Follow-on EELV acquisitions
- Restart of SLS RS-25 engine
- SLS Advanced Booster
- Advanced Upper Stage Engine
- Commercial Entrants

Metrics Studies: Collaborating with the Department of Commerce to develop and trend RPIB metrics and critical supplier pedigrees

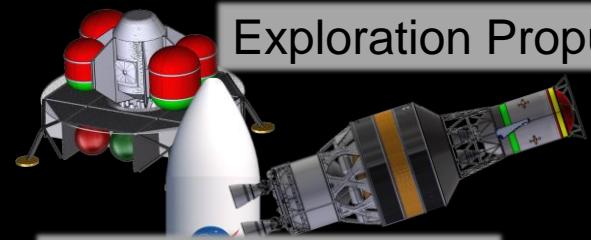


NIRPS Collaborates with all of the Equity Holders in Rocket Propulsion for the US Government

- The JANNAF Programmatic and Industrial Base (PIB) Executive committee integrates the working groups and has program, project and engineering senior managers
- The JANNAF PIB Senior Advisory Group consists of key senior executives and flag officers and sets the strategy for the JANNAF PIB
- NIRPS manages the JANNAF Administration and Support Contract
- NIRPS will leverage and support NASA Agency level initiatives through the Propulsion Capability Leadership Team, to provide analysis and recommendations



NASA MSFC Technology Development and Maturation Feeds NSS and Commercial Space



Exploration Propulsion Systems

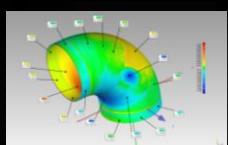


Upper Stage Engine

- LOX/Hydrocarbon engine design for booster and space exploration applications
- Additive Manufacturing
- Affordable RS-25 components
- Green Propellants
- Combustion stability analysis
- Lightweight cryogenic tanks
- Long duration cryogenic storage
- Advanced solid booster technologies
- Electric propulsion
- Structured Light Scanning



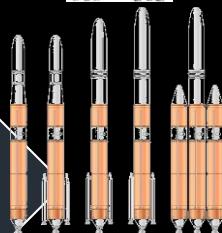
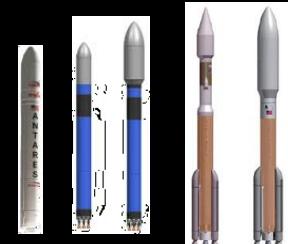
Advanced Boosters



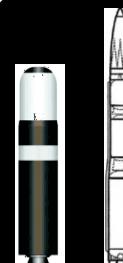
RS-25

Advanced Manufacturing Demonstration (AMD)

Next Generation Space Launch



NSS Space



RS-25 Affordability



**33% Reduction in
Engine Cost**

**>700 Welds Eliminated
>700 Parts Eliminated**



RS-25 Engine



SLS Solid Rocket Booster - Qualification Motor 1

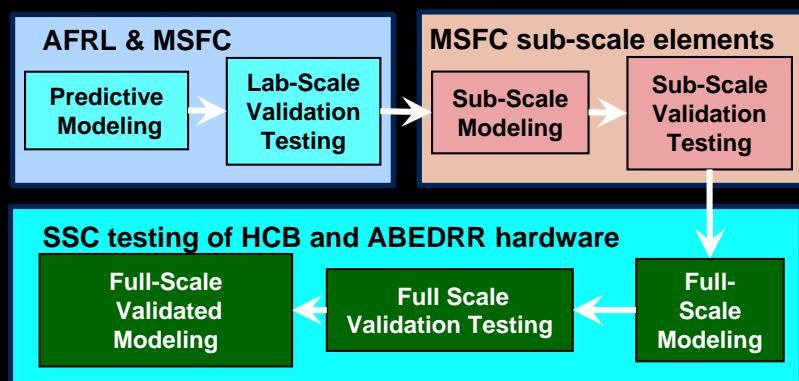
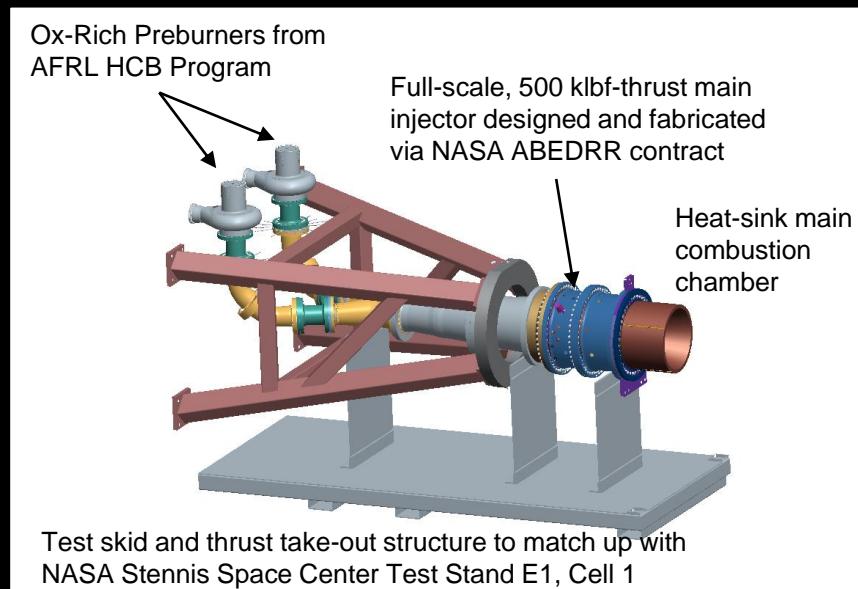




USAF SMC / NASA MSFC Launch and Propulsion Technology Maturation Efforts



- Integrated Ox-Rich Test Article (IOTA) – Full-scale (500klbf thrust), Lox/RP oxygen-rich staged combustion technology maturation effort
 - USAF Space and Missile System Center – coordination and funding source
 - NASA Advanced Booster Engineering Demonstration and Risk Reduction (ABEDRR) contract with Dynetics/Aerojet Rocketdyne
 - USAF Hydrocarbon Boost Program (HCB - conducted via AFRL)
 - NASA SSC unique facilities and experience – test stand E1
- Combustion Stability Technology Development – subscale oxygen-rich staged combustion stability demonstration, model development, and model validation
 - USAF Space and Missile System Center
 - Georgia Tech University
 - NASA MSFC
 - Air Force Research Lab
 - Purdue University



Retiring the Highest Risk of Combustion Stability

NASA MSFC Actively Pursuing Opportunities for Enhanced Design and Development via Advanced Manufacturing



Oxygen/hydrogen, open expander cycle, dual pumps w/ turbines in series

Technology development and demonstration to enable industrial advancement in rocket engine manufacturing

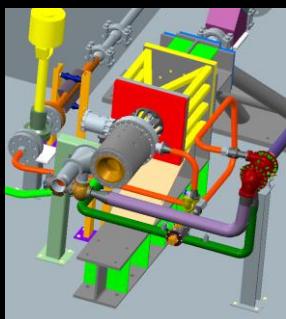


Parameter	Value	
Engine Height	< 90 in	
Engine Diameter	< 70 in	
Starts	15	
Life (Cumulative)	3,500 s	
Nozzle Exit Diameter	20.7 in	
Nozzle Area Ratio	26.92	
	70%	100%
Vacuum Thrust (lb _f)	24,828	35,352
Sea Level Thrust (lb _f)	~ 20,000	~ 27,000
Vacuum ISP (s)	451.9	452.0
Mixture Ratio (Inlet)	5.88	5.88
Mixture Ratio (TCA)	6.70	6.70
LH ₂ Flow Rate (lb _m /s)	8.0	11.37
LOX Flow Rate (lb _m /s)	47.0	66.85
Chamber Pressure (psia)	980	1,400
LH ₂ pump speed (RPM)	85,640	91,500
LOX pump speed (RPM)	21,900	27,500

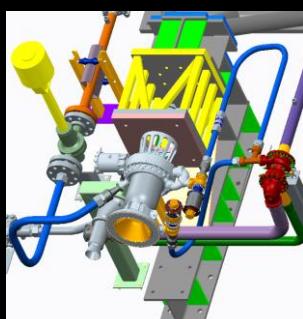
Breadboard Engine (current)

Incremental Development Path

Full Development Prototype Engine



Fuel pump/injector/ablative chamber (& valves, turbine bowls)



Add regeneratively-cooled combustion chamber



Add oxidizer pump (& more valve elements)

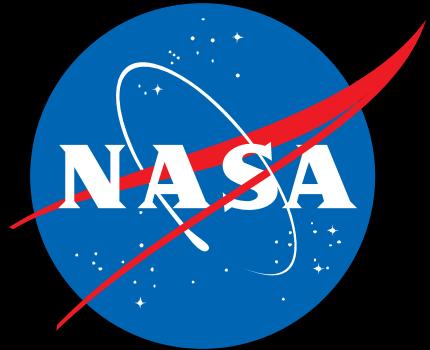


Add nozzle and system lines and ducts

Summary

- NIRPS is influencing US Government Policies by leading and supporting RPIB studies and analyses such as the NDAA 1095 Study, the PropSIMA Scenario Analysis Capability and the Domestically-Produced Engine Studies
- Via the JANNAF PIB, NIRPS is playing a leading role in integrating data and analysis and synchronizing programs across the rocket propulsion industrial base, providing senior leaders with the information needed to make informed decisions
- NIRPS is coordinating and advocating key propulsion technology advances and developments for a vibrant rocket propulsion industry

NIRPS has adapted its implementation strategies to the current environment



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Senior Advisory Group Membership

JANNAF Programmatic & Industrial Base Senior Advisory Group (SAG)				
Title	First Name	Last Name	Dept/Agency	Title
Dr.	L. Dale	Thomas (Co-Chair)	NASA	Associate Center Director, Technical, NASA/MSFC
Mr.	Andre'	Gudger (Co-Chair)	OSD	Deputy Assistant Secretary of Defense (Manufacturing & Industrial Base Policy) DASD (MIBP)
Dr.	Spiro G.	Lekoudis	OSD	AT&L/R&E/Research and Engineering
Mr.	Dyke	Weatherington	OSD	AT&L/SIO Deputy Assistant Secretary of Defense for Space and Intelligence
Mr.	Barry	Pike	USA	Deputy PEO, Missiles and Space
VADM	Terry	Benedict	USN	NAVY/Director Strategic Systems Programs
Dr.	Claire	Leon	USAF	Executive Director for Space Launch Enterprise
Dr.	Billy W.	Mullins	USAF	SAF/A-10 Assistant Chief of Staff, Strategic Deterrence & Nuclear Integration
			USAF	SAF/EA4S, Executive Agent for Space
Maj Gen	Scott	Jansson	USAF	AFPEO/SS Program Executive Officer for Strategic Systems
Mr.	William	Hill	NASA	NASA/HQ/CM Deputy Associate Administrator for Exploration Systems Development
Mr.	Benjamin	Neuman	NASA	NASA/HQ/CN Division Director for Human Spaceflight Capabilities
Mr.	Jim	Norman	NASA	NASA/HQ - Assistant Associate Administrator for Launch Services
Ms.	Karen	Borrows	USN	Executive Director/SEA 00VW Naval Ordnance Safety and Security Activity Indian Head, MD 20640
Ms.	Patricia	Gore	OSD/MDA	MDA/ECM Director, Industrial Manufacturing and Technology
Brig Gen Maj Gen	Anthony J. Steve	Cotton Denker (Summer 2015 process in)	NRO	Deputy Director, National Reconnaissance Office

PIB Executive Committee Membership

JANNAF Programmatic & Industrial Base Executive Committee (PEC)				
Title	First Name	Last Name		Affiliation
Dr.	Rajiv	Doreswamy (Chair)	NASA	NASA/MSFC
Mr.	Robert	Read (Co-Chair)	OSD	OSD-ATL
Dr.	Kendall	Brown (Alt Chair)	NASA	NASA/MSFC
Dr.	Christine	Michienzi	OSD	OSD-ATL
Mr.	Stuart	Blashill	USN	NAVY/China Lake
Mr.	Shahab	Chaudhry	USN	NAVY/SSP
Mr.	Frank	Tse	USN	NAVY/NSWCIHD
Mr.	Andy	Culbertson	OSD	OSD/R&E
Mr.	Drew	DeGeorge	USAF	AF/AFRL/RQR
Mr.	James	Fernandez	USAF	USAF/PEO/SP Space Launch Enterprise
Maj	Tim	Purcell	USAF	USAF/EA4S
Lt Col	Bill	Barrington	USAF	USAF/A10
Dr.	Jamie B.	Neidert	USA	ARMY/AMRDEC
Mr.	David	Tritt	USA	Army/PEO M&S
Mr.	John	Honeycutt	NASA	NASA/MSFC/SLS Program
Dr.	George	Schmidt	NASA	NASA/GRC
Mr.	Thomas	Williams	NASA	NASA/MSFC/Engineering
Lt Col	Mark	Cinnamon	NRO	NRO/OSL
Ms.	Megan	Meisner	MDA	Industrial Manufacturing and Technology

PIB Working Group Membership

JANNAF Programmatic & Industrial Base Large Liquid Propulsion Working Group

Title	First Name	Last Name	Affiliation
Dr.	Kendall	Brown (Lead)	NASA
Mr.	Drew	DeGeorge	USAF
Mr.	James	Fernandez	USAF
Maj	Lee	Kashka	USAF
Mr.	Bill	Jacobs	NASA
Mr.	George	Simone	NASA
Lt Col (s)	Tim	Purcell	USAF
Ms.	Dayna	Ise	NASA
Mr.	Robert	Read	OSD
Mr.	Kevin	Dickens	NASA
			NASA/GRC

JANNAF Programmatic & Industrial Base Large Solid Rocket Motor Working Group

Title	First Name	Last Name	Affiliation
Mr.	Shahab	Chaudry (Lead)	USN
Mr.	David	Olsen	USN
Dr.	Carlos	Lopez	USN
Dr.	Christine	Michienzi	OSD
Mr.	Alex	Priskos	NASA
Mr.	Mark	Cooper	NASA
Lt Col	Bill	Barrington	NASA
Mr.	Drew	DeGeorge	USAF
Mr.	Kirk	Newman	OSD
Mr.	Robert	Read	OSD
			OSD-ATL

JANNAF Programmatic & Industrial Base Small Liquid Propulsion Working Group

Title	First Name	Last Name	Affiliation
Mr.	Chuck	Pierce (Lead)	NASA
Mr.	James L.	Cannon	NASA
Mr.	James	Fernandez	USAF
Mr.	Drew	DeGeorge	USAF
Mr.	Robert	Read	OSD
Mr.	Dmitriy	Plaks	USA
Mr.	Kevin	Dickens	NASA
			NASA/GRC

JANNAF Programmatic & Industrial Base Small Solid Rocket Motor Working Group

Title	First Name	Last Name	Affiliation
Mr.	Frank	Tse (Lead)	USN
Mr.	Al	Stern	USN
Mr.	Nolan	Walton	USN
Mr.	Stuart	Blashill	USN
Dr.	Christine	Michienzi	OSD
Mr.	David	Tritt	USA
Mr.	Kevin	Blacklock	USA
Dr.	Jamie B.	Neider	ARMY/AMRDEC
Mr.	Drew	DeGeorge	AF/AFRL/RQR
Mr.	Mark	Cooper	NASA/MSFC
Mr.	Steven	Harrison	NASA/MSFC
Mr.	Kirk	Newman	OSD
Mr.	Robert	Read	OSD
			OSD-ATL/MIBP

JANNAF Programmatic & Industrial Base Science & Technology Working Group

Title	First Name	Last Name	Affiliation
Mr.	Drew	DeGeorge (Lead)	USAF
Mr.	James L.	Cannon	NASA
Mr.	Andy	Culbertson	OSD
Dr.	Christine	Michienzi	OSD
Mr.	Scott	Fuller	USN
Mr.	Mark D.	Klem	NASA
Mr.	Carlos	Lopez	USN
Ms.	Megan B.	Meisner	MDA
Dr.	Jamie B.	Neider	USAF
Mr.	Bob	Read	OSD
Mr.	David	Tritt	USAF
Mr.	Richard	Ryan	NASA
Mr.	Michael	Meyer	NASA
			NASA/GRC

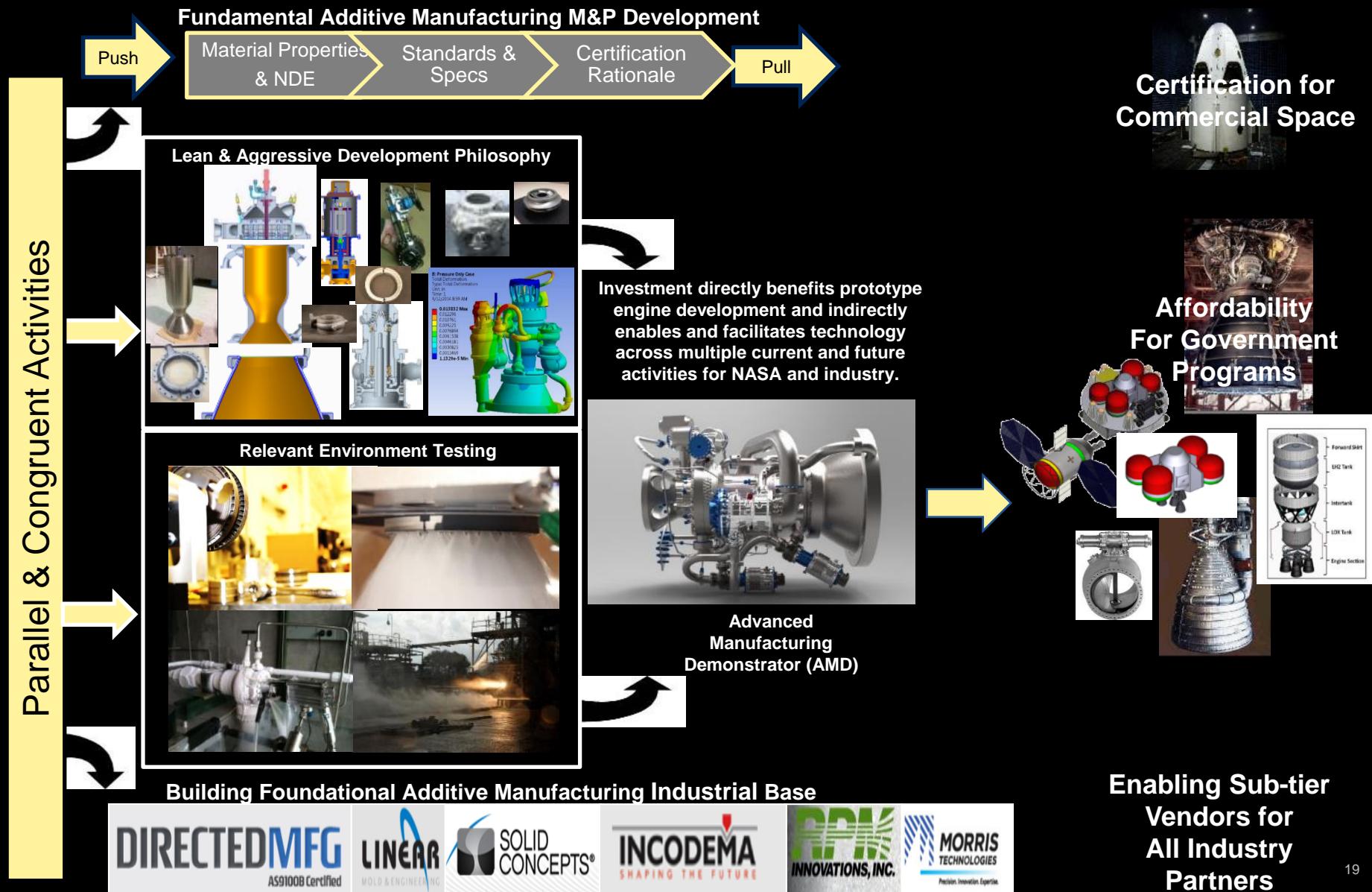
JANNAF Programmatic & Industrial Base Test & Evaluation Working Group

Title	First Name	Last Name	Affiliation
Mr.	Mark	Moody (Lead)	NASA
			NASA/SSC/RPT/TA00

JANNAF Programmatic & Industrial Base Electric Propulsion Working Group

Title	First Name	Last Name	Affiliation
Mr.	David	Jacobson	NASA
			NASA/GRC

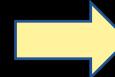
NASA MSFC Actively Pursuing Opportunities for Enhanced Design and Development via Advanced Manufacturing to Enable Future Propulsion



Investment directly benefits prototype engine development and indirectly enables and facilitates technology across multiple current and future activities for NASA and industry.



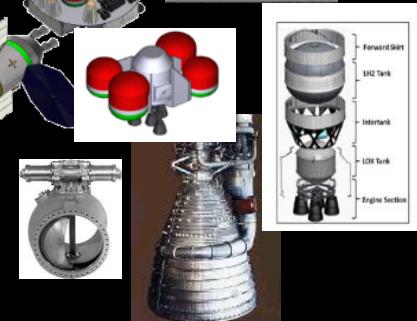
Advanced Manufacturing Demonstrator (AMD)



Certification for Commercial Space

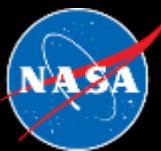


Affordability For Government Programs



Enabling Sub-tier Vendors for All Industry Partners

Using Actual Design, Development, and Test Activity to Learn the New Paradigms of Advanced Manufacturing



Test Stand 116



MCC Liner



Main Fuel Valve
Cryogenic Test



Full Scale
Injector
Water Flow



Sub-scale Injector Test



Turbine Exhaust Bowls



Turbine
Test Rig



Fuel Pump Assembly



Injector Assembly



Using Actual Design, Development, and Test Activity to Learn the New Paradigms of Advanced Manufacturing

